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APPARATUS AND METHOD FOR SELF-CENTERING
A WAFER IN A SPUTTER CHAMBER

Field of the Invention

001 The present invention generally relates to an apparatus and a method for loading a wafer into a physical vapor deposition chamber and more particularly, relates to an apparatus and a method for self-centering a wafer onto a wafer pedestal situated in a physical vapor deposition chamber.

Background of the Invention

002 Physical vapor deposition (PVD) or sputter deposition is a frequently used processing technique in the manufacturing of semiconductor devices that involves the deposition of a metallic layer on the surface of a semiconductor device. The physical vapor deposition technique is more frequently known as a sputtering technique. In more recently developed semiconductor fabrication processes, the sputtering technique is used to deposit metallic layers of tungsten or titanium tungsten as contact layers.

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003 In a sputtering process, inert gas particles such as those of argon or nitrogen, are first ionized in an electric field to produce a gas plasma and then attracted toward a source or a target where the energy of the gas particles physically dislodges, i.e., sputters off, atoms of the metallic or other source material. The sputtering technique is very versatile in that various materials can be deposited utilizing not only RF but also DC power sources.

004 In a typical sputter chamber, the major components utilized include a stainless steel chamber that is vacuum-tight and is equipped with a helium leak detector, a pump that has the capacity to reduce the chamber pressure to at least 10^{-6} torr or below, various pressure gauges, a sputter source or target, a RF or DC power supply, a wafer holder, a chamber shield and a clamp ring. The sputter source is normally mounted on the roof of the chamber such that it faces a wafer holder positioned in the center of the chamber facing each other. The sputter source utilized can be a W or TiW disc for a process in which W or TiW is sputtered. A typical sputter chamber is that supplied by the Applied Materials, Inc. of Santa Clara, CA. under the trade name of Endura® 5500. In

some of the sputter chambers, the wafer holder is structured as a pedestal which includes an internal resistive heater.

005 One of the more important component in the sputter chamber is the clamp ring which serves two purposes during a sputter process. The first purpose is to clamp the wafer to the pedestal heater. The clamp ring holds the wafer in place on the pedestal when a positive gas pressure is applied between the heater and the pedestal such that heat can be efficiently conducted from the heater to the wafer. The second purpose served by the clamp ring is to allow a predetermined flow of argon to leak from under the wafer into the sputter chamber. The clamp ring is generally constructed in a circular shape with an oriented cut-out to match a wafer's flat contour. A hood is built into the clamp ring and is used for shadowing purpose to protect the lip of the clamp ring from being coated by the sputtered metal particles. The lip portion also allows the force of the clamp ring to be evenly distributed around the wafer.

006 A cross-sectional view of a typical sputter chamber 10 is shown in Figure 1. Sputter chamber 10 is constructed by a stainless steel chamber body 12 that is vacuum-tight, a sputter

target 16 of W, TiW or Sn, a wafer holder 20 equipped with a heater 22, a wafer lift mechanism 24, a wafer port 28, a pumping port 32, a clamp ring 30 and a chamber shield 34. A DC power supply 25 is connected to a target 21 and a conductive part of the chamber, such as the chamber wall 18 or chamber shield 34, thereby establishing a voltage potential between the grounded chamber wall 18 and the target 21. A DC bias circuit 23 is connected to the clamping ring and thus applies a DC bias to the wafer (not shown). The hood 36 of the clamp ring 30 protects the tip 38 from being coated by the sputtered particles. A perspective view of the same sputter chamber 10 is shown in Figure 2.

007 As shown in Figure 1, the chamber shield 34 is another important component in the sputter chamber 10. It forms a seal between the clamp ring 30 and the chamber body 12 such that sputtered particles from the sputter target 16 do not contaminate the chamber wall 18 during a sputtering process. It should be noted that, during the sputtering process, the wafer pedestal 20 is in a raised position with the tip portion 38 of the clamp ring 30 touching the heater 22 on the pedestal 20. In order to achieve a tight seal from the chamber wall 18, a small gap 40 is normally maintained between the clamp ring 30 and the chamber shield 34. In

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a typical metal sputtering process where a W, TiW, Sn or other metal is used in the sputter chamber, the emission of sputtered particles of the metals is shaped with a forward cosine distribution such that a more desirable deposition process in which metal particles are deposited uniformly at the center and the edge of the wafer can be achieved.

008 One of the processing difficulties incurred in a sputtering chamber is the placement of the wafer on the wafer pedestal. When a wafer is not positioned at a perfectly centered position on a wafer pedestal, i.e., the wafer position has shifted away from the center, subsequent metal deposition process produces a wafer that has thinner coating on one edge which will then lead to defocusing during photolithography resulting in defective dies being produced on the wafer edge. The defective dies result in a low yield of the physical vapor deposition process. It is therefore an important task during the fabrication process to center a wafer on a wafer pedestal properly before a deposition is to take place.

009 It is therefore an object of the present invention to provide an apparatus for self-centering a wafer on a wafer pedestal that does not have the drawbacks or shortcomings of the conventional apparatus.

010 It is another object of the present invention to provide an apparatus for self-centering a wafer on a wafer pedestal situated in a physical vapor deposition chamber that does not require any additional processing step.

011 It is a further object of the present invention to provide an apparatus for self-centering a wafer on a wafer pedestal in a sputtering chamber by using a modified wafer lifter equipped with at least four support fingers.

012 It is another further object of the present invention to provide a wafer lifter for self-centering a wafer on a pedestal by providing four support fingers on a lifter body that are each equipped with a slanted surface for contacting the wafer and for performing the self-centering function.

013 It is still another object of the present invention to provide a wafer lifter for self-centering a wafer on a pedestal situated in a physical vapor deposition chamber by utilizing a modified hoop equipped with improved support fingers.

014 It is yet another object of the present invention to provide a method for self-centering a wafer on a wafer pedestal by utilizing a modified wafer lifter equipped with improved wafer support fingers.

Summary of the Invention

015 In accordance with the present invention, an apparatus and a method for self-centering a wafer on a wafer pedestal in a physical vapor deposition chamber are provided.

016 In a preferred embodiment, a wafer lifter for self-centering a wafer on a pedestal may be provided which includes a lifter body of annular shape that has a center cavity with a diameter that is larger than a diameter of the wafer pedestal; at least four support fingers emanating upwardly from the lifter body and are spaced-apart from each other; and a platform on a tip portion of each of the at least four support fingers defined by a

surface slanted from a vertical plane of an outside surface of the support finger; the platform, when supporting a wafer thereon, leaves substantially no gap between the slanted surface and an outer periphery of the wafer.

017 In the wafer lifter for self-centering a wafer onto a wafer pedestal, the platform may be defined by a slanted shoulder portion of the support finger. A base of the slanted shoulder portion of the support finger defines a diameter of a circular area surrounded by the platforms of the at least four support fingers which is not larger than a diameter of the wafer when measured at 23°C. The at least four support fingers may be substantially equally spaced-apart from each other. The platform, when supporting a wafer thereon may leave a gap smaller than 0.5 mm between the slanted surface and the outer periphery of the wafer. The lifter body may be fabricated of a material that has a rigidity of at least that of aluminum. The lifter body may be equipped with four support fingers emanating upwardly from the body, or the four support fingers may be emanating upwardly at a 90° angle from the body. The lifter body may have a ring shape.

018 The present invention is further directed to a method for self-centering a wafer on a wafer pedestal which can be carried out by the operating steps of first providing a wafer lifter that includes a lifter body of annular shape that has a center cavity with a diameter that is larger than a diameter of the wafer pedestal, at least four support fingers emanating upwardly from the lifter body and are spaced-apart from each other, and a platform on a tip portion of each of the at least four support fingers defined by a slanted surface from a vertical plane of an outside surface of the support finger, the platform when supporting a wafer thereon leaves no gap between the slanted surface and an outer periphery of the wafer; positioning a wafer on the wafer lifter supported by the platform on the tip portion of the at least four support fingers; and lifting the wafer lifter to a position over the wafer pedestal and depositing the wafer onto the pedestal.

019 The method for self-centering a wafer on a wafer pedestal may further include the step, after the lifting step, of lowering the wafer lifter to deposit the wafer onto the wafer pedestal, or the step of sputter depositing a metal layer on a top surface of the wafer. The method may further include the step of self-centering the wafer on the wafer lifter during the positioning step

when the wafer is guided into a center position by the sloped surface on the tip portion of the at least four support fingers, or the step of providing four support fingers that are vertically mounted on the lifter body. The method may further include a step of fabricating the lifter body with a material that has a rigidity of at least that of aluminum, or the step of fabricating the lifter body with aluminum or stainless steel.

Brief Description of the Drawings

020 These and other objects, features and advantages of the present invention will become apparent from the following detailed description and the appended drawings in which:

021 Figure 1 is a cross-sectional view of a conventional physical vapor deposition chamber illustrating a wafer lifter situated inside the chamber.

022 Figure 2 is a perspective view of the conventional physical vapor deposition chamber of Figure 1.

023 Figure 3 is a perspective view of the present invention wafer lifter with improved wafer support fingers.

024 Figure 4A is a cross-sectional view illustrating the present invention wafer lifter in a lifted position.

025 Figure 4B is a cross-sectional view of the present invention wafer lifter in a wafer released position.

026 Figure 4C is a cross-sectional view of the present invention wafer lifter in a process position.

027 Figure 5A is an enlarged, cross-sectional view of the tip portion of a conventional support finger.

028 Figure 5B is an enlarged, cross-sectional view of the tip portion of a present invention support finger.

Detailed Description of the Preferred Embodiment

029 The present invention discloses an apparatus and a method for self-centering a wafer onto a wafer pedestal situated in a physical vapor deposition chamber, i.e., in a sputter chamber.

030 The apparatus of a wafer lifter is used for self-centering a wafer onto the pedestal which is constructed by a

lifter body of annular shape that has a center cavity with a diameter larger than a diameter of the wafer pedestal; at least four support fingers emanating upwardly from the lifter body at approximately 90° and are substantially equally spaced apart from each other; and a platform on a tip portion of each of the at least four support fingers defined by a slanted surface as measured from a vertical plane of an outside surface of the support finger. When a wafer is supported by the platform of each of the at least four support fingers, substantially no gap is formed between the slanted surface and the outer periphery of the wafer.

031 Referring now to Figure 3, wherein a present invention wafer lifter 40 is shown. The wafer lifter consists of a lifter body 42 formed of an annular, or ring-shape with a center cavity 44. The center cavity 44 has a diameter that is larger than a diameter of the wafer pedestal 20 (shown in Figure 2) such that a wafer can be loaded onto the pedestal 20 when the lifter 40 is lowered onto the pedestal. The lifter body 42 further includes at least four support fingers 46 each emanating upwardly from a top surface 48 of the lifter body 42 and are spaced-apart from each

other. In the configuration shown in Figure 3, the four support fingers 46 are spaced-apart from each other at substantially the same distance.

032 An enlarged, detailed view of the support finger 46 of the lifter body 42 is shown in Figure 5B. It is seen that the support finger 46 has a tip portion 48 defined by a slanted surface 50 which is slanted from a vertical plane of an outside surface 52 of the support finger 46. The platform 54, when support a wafer 60 thereon, leaves substantially no gap between the slanted surface 50 and an outer periphery 56 of the wafer 60.

033 The support finger 46 can be compared, in contrast, to a conventional support finger 70 shown in Figure 5A. The conventional support finger 70 is equipped with a slanted surface 72, however, intercepted by a vertical surface 74 and thus leaving a gap "A" between the vertical surface 74 and the outer periphery 56 of the wafer 60. The gap "A" shown in Figure 5A is the major contributing factor for wafer shifting during a wafer loading process onto a pedestal leading to deposition and quality problems.

034 Referring now to Figure 5B, a base 58 of the slanted shoulder portion 48, or the tip portion, of the support finger 46 defines a diameter of a circular (not shown) surrounded by the platforms 54 of the at least four support fingers. The circular area formed is not larger than a diameter of the wafer to be carried by the support fingers when measured at room temperature, i.e., at about 23°C. The design is such that when the wafer lifter is used in a fabrication process, the high temperature of the sputter chamber expands the wafer lifter and thus a small gap, such as 0.5 mm, between the wafer and the slanted shoulder portion is provided.

035 The present invention further discloses a method for self-centering a wafer onto a wafer pedestal situated in a physical vapor deposition chamber. The method can be carried out by first providing a wafer lifter as described above, then positioning a wafer on the wafer lifter 40, as shown in Figure 4A, supported by the platform 54 on the tip portion of the support fingers 46. The wafer lifter 40 is then lifted to a position over the pedestal 20 and the wafer is deposited on to the pedestal 20, as shown in Figure 4B. It should be noted that other than the components described above, Figures 4A, 4B and 4C also show a clamp ring 30

which was discussed in Figure 1. Similarly, a chamber shield 34 is also shown in these Figures and was discussed in Figure 1.

036 In the final stage of the process, as shown in a process position in Figure 4C, the wafer pedestal 20 is moved up to the process position, i.e., the edge of the wafer 60 is covered by the clamp ring 30 while the wafer lifter 40 is released from the pedestal 20.

037 The present invention novel apparatus and method for self-centering a wafer onto a wafer pedestal in a physical vapor deposition chamber have therefore been amply described in the above descriptions and in the appended drawings of Figures 3, 4A-4C and 5B.

038 While the present invention has been described in an illustrative manner, it should be understood that the terminology used is intended to be in a nature of words of description rather than of limitation.

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039 Furthermore, while the present invention has been described in terms of a preferred embodiment, it is to be appreciated that those skilled in the art will readily apply these teachings to other possible variations of the inventions.

040 The embodiment of the invention in which an exclusive property or privilege is claimed are defined as follows.